Klein also hopes to help the engineer directly. The problems taken up by University men are at present without direct connection with practical needs, simply because the latter are unknown at the Universities. Klein wants to make these needs known to the University teachers in order to make it possible to direct their energies in the channels useful to engineers. Again, by having at hand a technical laboratory, and having connected with this all the intellectual resources of the University, it will be possible to bring to bear on technical problems such scientific power as is not likely to be found elsewhere.

To the same end he wishes to make important English scientific papers on technical subjects accessible to German physicists and engineers through translations, and a beginning will be made with Prof. Osborne Reynolds' paper on "Friction of Lubricated Bearings." Dr. Routh's "Rigid Dynamics" will also be translated.

It will be seen from this that Klein's scheme does not affect the ordinary education of engineering students, but that he takes a far higher flight which will not affect the routine at the high schools. Indirectly it cannot fail to raise the whole profession, the whole education of Germany; and if it is carried out in the spirit in which it is conceived, and is ably supported by his colleagues, it will have far-reaching consequences.

That the original memorandum did not reveal the full meaning of Klein's scheme can be explained by supposing that he had himself suffered from the want of direct contact with the engineering profession, and, besides, by his taking it for granted that every one would understand that he was speaking only of the *highest* part of the education of engineers, and that he did not dream of establishing a new engineering school to compete with the old ones.

As soon as he became aware of the opposition raised, he tried by personal intercourse to put himself right, and to destroy the false impression originally created. He went to meetings of the Engineer's Verein at Aachen and Hanover, in 1895, and expounded his plans, with the result of converting many to his views. When he found that the high schools were preparing schemes for laboratories of their own, he at once gave up all idea of asking the Government for money, considering that here the high schools had the first claim, and set about to make private means available in English and American fashion. He succeeded in interesting influential and wealthy manufacturers in his cause, who formed a committee which has promised and guaranteed him a sum sufficient to start one laboratory. For this purpose the thermodynamic laboratory has been selected, and is now in course of erection. As to the choice of a director, he has asked Prof. Linde's advice, who has recommended a pupil of his own; and all will agree that Linde's name is sufficient guarantee that the new director has been educated in a truly practical spirit.

Prof. Klein's plan does not in the least collide with the legitimate aims of the technical high schools; such collision only takes place with regard to the education of teachers, and here the claims of Riedler and others seem to us to be altogether unreasonable.

Klein is altogether the right man to carry out the plan successfully. His singleness of mind is conspicuous to every one who has come, however slightly, in contact with him. As a mathematician he is known and honoured all the world over. He possesses a strong faculty for geometrical conceptions, and likes, with wonderful success, to clothe every mathematical investigation in a geometric garb, or to illustrate it geometrically. His book on the *Ikosaeder* is a brilliant example of this. He, more than any other, has tried to remain in contact with the school teachers of mathematics, and has often put the results of profound mathematical speculations in such a form that they become available for school teaching.

To make the teaching of geometry more real he started, when Professor at the Munich Technical High School, the modelling of surfaces by the students; and the whole large collection of models on sale by Brill in Darmstadt may be said to have grown out of this. For the same reason, he has introduced at the University a course of geometrical drawing. He dwells not less on the necessity of developing facility in performing arithmetical calculations.

All engineering teachers in England will wish that English schoolmasters had been drilled in these two directions.

By descent, and from the environments in which he grew up, he has, from his youth, been familiarised with industry and manufacture.

The traditions of Göttingen, too, are greatly in his favour, and have helped to ripen his plans. Here Gauss worked for years at all possible problems ranging from pure abstract theory of numbers to the invention of an electric telegraph, and of a method of signalling by the sun's rays, now so extensively used in the English army. He enriched science as well as engineering with many important gifts; the theory of least squares, the absolute measure of force, the theory of magnetism, and all his work in connection with Weber.

What Gauss did alone, that Klein wishes to continue in combination with others; he justly observes, also, that a small town is more suited for his experiment than a large town with all its distractions.

We can only wish him success in his bold undertaking, and feel sure that, even if German engineers should carry their antagonism so far as to try to starve his undertaking by preventing young men from making use of the opportunity he offers them, which is most improbable, there will come to him, as heretofore, many eager students from England and America.

O. HENRICI.

A WELL-KNOWN TEXT-BOOK OF CHEMISTRY.

A Manual of Chemistry, Theoretical and Practical (based on Watts' edition of Fownes' Manual). By William A. Tilden, D.Sc., F.R.S. Pp. xvi + 599. (London: J. and A. Churchill, 1897.)

THE preface to the original edition of Fownes' *Manual* is dated October 5, 1847. The merits of that book, published about half a century ago, were known to all. But, inasmuch as Prof. Tilden says in his preface to the present work "the last traces of Fownes have disappeared in the process" of re-writing, it is a manual of chemistry by Dr. Tilden, and not Fownes' book, that is to be reviewed here.

The task undertaken by the reviewer is a difficult one. I have tried to discover the principles on which the book is constructed, and to follow the method whereby these principles are applied. I trust, and I expect, that the criticisms I make will not be regarded by the author as the flippancies of an irresponsible reviewer, but that he will believe I am serious and as anxious as he is, up to my lights, to promote the study of chemistry.

What is the subject-matter of chemistry? If I am justified in taking this book as (among other things) Dr. Tilden's answer to that question, then, in my opinion, the answer is wrong.

The opening sentence of the *Introduction* reads well.

> "The science of chemistry has for its object the study of the composition of the materials out of which are formed the earth, the sea, the air, and the organised and living beings which inhabit them. Chemistry also seeks to explain the composition of bodies and their properties."

If this is taken with the statement on page 12,

> "it is no longer sufficient to determine composition. The aim of the chemist is to ascertain the relation of composition to the physical properties of a body,"

we have a description of the subject-matter of chemistry which seems to me fairly adequate. Would it not have been better to have omitted the word *physical* in the last sentence of the words quoted?

But the book does not fulfil the promise of the *Introduction*. The study of the compositions of bodies; the study of the properties, especially the reactions, of bodies; and the study of the connections between the compositions and the properties of bodies; that, surely, is the business of chemistry. And the one method by which this business can be conducted successfully is the comparative method. If a student is to acquire a genuine knowledge of that branch of natural science called chemistry, it seems to me he must be led constantly to compare and contrast facts in order that he may be prepared to receive, and comprehend, the generalisations of the science. The foundation cannot be laid firmly unless the builder is thinking of the structure he means to raise upon it. To vary the illustration: if the student of chemistry has shot over him loads of sterilised facts he soon is smothered; and if attempts are made to restore him by drawing him out now and then and submitting him to a cold douche of theory, the spark of life that was left in him is likely to be washed away.

After carefully reading much of this book, I am driven to the conclusion that it fails to connect the facts it records with one another, and with the generalisations which rest on the facts, marshal these facts into order, and suggest other facts. Moreover it seems to me that the generalisations of the science are not stated with sufficient fulness, lucidity, and suggestiveness; that the hypotheses of chemistry are not enunciated in such a way as makes it possible for the student to hold them firmly in his mental grasp, and at the same time to be ready to let them go when they have served their purpose of aiding clear thinking; and that the theories of chemical science are not brought into just proportion with the facts and the hypotheses which they ought to bind together and to vitalise.

I admit the enormous difficulty of dealing accurately, lucidly, and suggestively with the vast quantity of facts that has been accumulated by the labours of generations of chemists. I admit the insuperable difficulty of fitting all the many hypotheses of chemistry into their proper places. I do not deny the impossibility of treating the theories of the science, especially in an elementary book, so as to command the assent of so fractious a fraternity as the chemists. Still I think that a serious and painstaking effort should be made by every writer of a manual of chemistry to compare and contrast facts with facts, and to show that the hypotheses and the theories of the science rest on, while they pass beyond, and illuminate, the facts of the science.

It would be manifestly unfair, even in a review to which the writer's name is attached, to find such fault with a book as I have found with Dr. Tilden's *Manual*, without going into some details to justify the fault-finding.

On pp. 16 to 20 a brief account is given of chemical nomenclature and notation. The facts regarding the compositions of compounds which are conveyed by chemical formulæ are expressed in these pages in the language of the theory of atoms. But that theory has not been explained to the student; it has been sketched in the merest outline only. Indeed the theory could not be explained at this early stage of the student's progress. This method seems to me to be entirely wrong; I am certain it cannot conduce to correct thinking.

The *Introduction* is followed by chapters wherein are recounted, and illustrated, the preparations, and some of the properties, of the non-metallic elements and their more important compounds. These chapters also contain lucidly written accounts of those general properties of gases which are of importance to the chemist; of the structure of flame; of some of the phenomena of solution; and of other important matters. Then follow chapters on the laws of combination, the atomic and molecular theory, classification, crystallisation, allotropy and isomerism, heat and chemical affinity, and electrolysis. These are succeeded by accounts of the preparations and properties of the metals and the compounds of the metals.

It is not with the chapters or paragraphs which convey information about the elements and their compounds that I find fault. Much, I think one may say most, of what is contained in these chapters is written clearly and accurately; a selection is made—I think on the whole a good selection—from the enormous number of those facts which are the building stones of the edifice of chemistry. What I complain of is that these building stones are not employed to construct a building; they are arranged in heaps, and each heap is duly labelled;—but, that is all. If chemistry is a collection of bundles of information loosely held together by a few strings of generalisation, then the method of this book is excellent. The separate pieces of information are conveyed in clear and accurate terms. But, in my opinion, the binding strings are very fragile and they do not prevent the contents of the bundles from being scattered.

Many of the chapters which deal with the principles of the science are unsatisfactory. The *laws relating to combining proportions* are enunciated on pp. 236 to 238 These laws are not stated in sharp and decisive terms For instance

> "The *law of definite proportions* affirms that when two substances unite together to form a given compound they can unite only in a fixed proportion ; . . ."

Why "*two substances*"? What exactly is "*in a fixed proportion*"? Why "they *can* unite"? Would not a student find much difficulty in understanding the conclusion that is drawn from the law of reciprocal proportions? This conclusion is

> "For each element, therefore, there is a fixed proportion in which it enters into any state of chemical union."

The laws of chemical combination cannot be understood without the help of examples worked out fully from the basis of analytical and synthetical data. I cannot find in these pages any statement of the nature of the evidence whereon these fundamental laws rest ; nor can I discover any suggestion of the vast importance of these generalised statements of facts—the laws of chemical combination—which we have every reason to regard as true natural laws.

On p. 238 sixteen lines are devoted to *the atomic theory of Dalton*. I am certain that no student could obtain, from the author's statement of this theory, a clear mental image of the Daltonian conception of the atom. On this page occurs the statement

> "a group of atoms united together chemically is called a molecule."

And on p. 240, after the enunciation of the law of Avogadro, we read

> "by a molecule is here understood a small portion of the substance of the gas made up of atoms which do not separate from one another during the movements of the molecule."

This is altogether insufficient. Reference is made, it is true, to "Kinetic Theory, p. 239"; but no clear and sufficiently detailed statement of what is to be understood by the word *molecule* is to be found in the paragraphs devoted to that theory.

As regards the methods employed for determining the relative weights of molecules and the relative weights of atoms, I do not think that a student of fair intelligence and perseverance will be able to realise these methods as definitely as they ought to be realised, even by a very careful consideration of the paragraphs devoted to these subjects on pp. 241 to 251. About 10 pp., 254 to 264, are concerned with the very difficult subject of *valency* or *atomic value* and the application thereof to constitutional formulæ.

> ". . . an atom of certain elements can replace or be substituted for only one atom of hydrogen, whereas the atoms of other elements can replace 2, 3, 4, &c., atoms of hydrogen."

Then follow reactions meant to illustrate this statement. And then we read

> "This difference of combining or saturating power, originally called *atomicity*, now more appropriately called *valency*, is sometimes denoted by placing dashes . . ."

This is, in my opinion, slipshod and hazy writing, and it cannot but induce to slipshod and hazy thinking.

There is an extraordinary statement on pp. 255, 256 about *the law of even numbers*. This "law," we are told, is that

> ". . . in all such compounds [saturated or normal compounds] the sum of the perissad elements (that is, elements whose atoms are of uneven valency) is always an even number."

Take the case of the gaseous molecule NO. *The sum of the perissad elements*, to use the author's loose phrase, in this compound is not an even number. Perhaps this compound is not a "saturated or normal compound"? Well, define what you mean by "saturated or normal," and then show that *the law of even numbers* is of any value as an aid to accurate research and accurate thinking. The existence of the three gaseous molecules InCl, $InCl_2$, $InCl_3$ disposes of the law of even numbers, if the *law* is anything more than a mere playing with numbers.

I have tried to get some clear notions about *heat and chemical affinity* from the pages which deal with that subject ; but I have failed. These pages give one a little information about some portions of thermal chemistry ; but the subject of chemical affinity is not really touched on at all.

On p. 287 there is a guarded, but still misleading, statement which comes perilously near an enunciation of Berthelot's *law of maximum work*, which "law" is both false in fact and untrue in principle.

To sum up the complaints I make against this book. There is a want of proportion. There is a failure to appreciate the relative importance of the various parts of the science. There is a failure to describe facts of observation as such, and then to show how hypotheses arise and react on these facts, until a general theory is attained, which illuminates the foundations whereon it rests, and suggests the lines on which search must be made for more facts.

I admit the vast difficulty of writing an elementary manual of chemistry. The past is strewn with failures, to which I have myself contributed. I am exceedingly sorry to say that, in my opinion, this book is not a success.

M. M. PATTISON MUIR.

PHILOSOPHY AND PHILOSOPHERS.

History of Philosophy. By Prof. A. Weber. Translated by Dr. F. Thilly. Pp. xi + 630. (London : Longmans and Co., 1896.)

System der Philosophie. Von W. Wundt. Zweite umgearbeitete Auflage. Pp. xviii + 689. (Leipzig : Engelmann, 1897.)

FOR Prof. Weber the chief interest of his subject obviously lies in the post Kantian schools, and his own solution of the problem of philosophy, as shaped by the influence of the conceptions and methods of the natural sciences on the one hand, and by the exigencies of ideal and optimist ethics on the other, is in the direction of a "concrete spiritualism." The key-word of this he finds in will or force rather than reason, but a *Wille zum Guten* in place of Schopenhauer's will to live. It is in virtue of his firm hold upon modern problems that his review of the way in which they have been historically evolved is so far successful that some, at least, of the dry bones of the History of Philosophy are made to live. Those writers whose antagonism to a dualist metaphysic makes them forerunners of the post-Kantian development—Bruno for example, and